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Understanding the Origin of Magnetism in MN Doped GE

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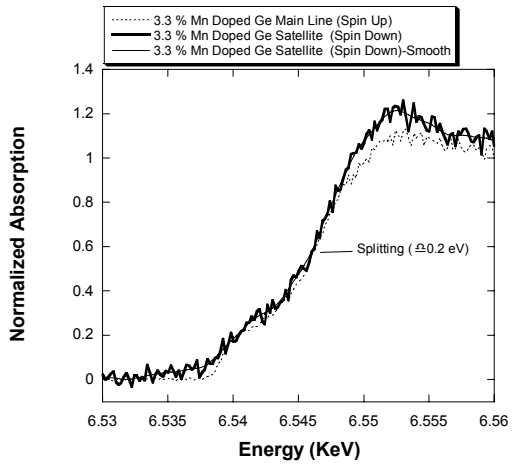
Introduction and Results: The origin of ferromagnetism in the magnetic semiconductors is still not resolved although it is accepted that ferromagnetism is due to an effective interaction between magnetic ions mediated by mobile carriers. A broad group of models exist with "qualitative differences" [1]. To understand these materials from a fundamental perspective and to optimize their magnetic properties (T_c and net magnetic moment) it is necessary to quantify the disorder of the introduced magnetic ions and to determine the magnetic ion's net spin and valence. The degree of covalency has a direct impact on modeling of exchange functions J and J_{AF}. Building on experience gained with the manganite system [2] we have studied the total spin on the Mn sites in Mn doped Ge films (~ 100 nm thick) grown by MBE at NRL [3]. This was carried out by measuring spin polarized XANES spectra and examining the spin dependent splitting of the edges based on comparisons with well characterized standards (Fig 1).

Our primary result is that Mn exists in a low-spin state with a moment of ~1 Bohr Magneton per Mn site. In future experiments, field dependent and temperature dependent experiments will be carried out to explore the thermal and field evolution of the moments on the Mn sites**.**

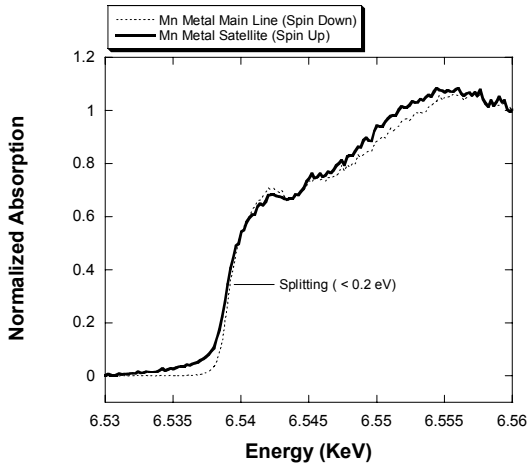
References:

[1] A. Chattopadhyay, S. Das Sarma and A. J. Millis, Physical Review Letters **87**, 227202/1 (2001).
[2]] Q. Qian, T. A. Tyson, C. C. Kao, M. Croft, and A. Y. Ignatov, Appl. Phys. Lett. **80**, 3141 (2002) and references therein.
[3] Y. D. Park, A. T. Hanbicki, S. C. Erwin,C. S. Hellberg,J. M. Sullivan,J. E. Mattson,T. F. Ambrose, A. Wilson,G. Spanos and B. T. Jonker, Science (Washington, DC, United States) **295**, 651 (2002).
[4] A. K. Cheetam and D. A. Hope, Phys. Rev. B **27**, 6964 (1983).
[5] D. Hobbs and J. Hafner, J. Phys.: Condensed Matter **13**, L681 (2001) and references therein.

(a)



(b)



(c)

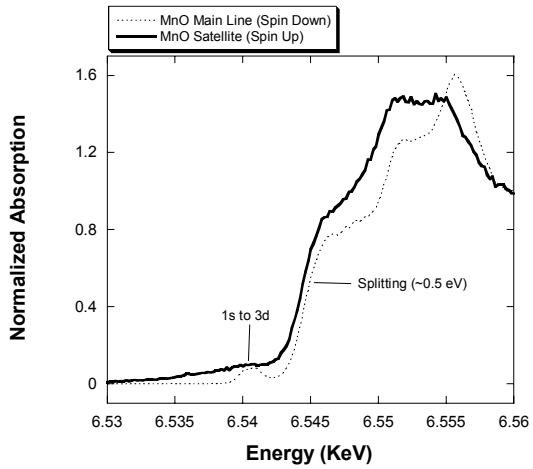


Figure 1. Spin polarized near edge absorption spectra of $Ge_{0.967}Mn_{0.033}$ (a) compared with Mn metal (b) and MnO (Mn^{2+}) (c). These measurements are sensitive to the magnitude of the local moment on the Mn site [2]. In MnO, with a measured Mn net moment of 4.58 μ_B per Mn ion [4] a splitting of the spin-up and spin down channel is observed due the difference between the spin up and spin down potentials seen by the excited electron. In addition, spin down transitions to the 3d region exhibit a peak in the absorption spectrum while no such peak occurs for (spin up) transition to the filled 3d states. In Mn Metal a small splitting of the spin spectra is observed and no 1s to 3d transition is seen. This is consistent with the measured low spin state of α-Mn metal with an average absolute moment per Mn site of 1.2 μ_B [5]. From this comparison we note that, the splitting in $Ge_{0.967}Mn_{0.033}$ is on the order of that found in Mn metal. Moreover, no 1s to 3d peak is observed. **Hence Mn in $Ge_{0.967}Mn_{0.033}$ exists in a low spin state and has a moment per Mn close to that of Mn metal.**